U.S. DEPARTMENT OF ENERGY
DEPARTMENT-WIDE
FUNCTIONAL AREA QUALIFICATION STANDARD

ELECTRICAL SYSTEMS QUALIFICATION STANDARD

Defense Nuclear Facilities Technical Personnel

U.S. Department of Energy
Washington, D.C. 20585

May 1995

Approval and Concurrence

The Associate Deputy Secretary for Field Management is the Management Sponsor for the Department-wide Electrical Systems Functional Area Qualification Standard. The Management Sponsor is responsible for reviewing the Qualification Standard to ensure that the technical content is accurate and adequate for Department-wide application. The Management Sponsor, in coordination with the Human Resources organization, is also responsible for ensuring that the Qualification Standard is maintained current. Concurrence with this Qualification Standard by the Associate Deputy Secretary for Field Management is indicated by the signature below.

The Technical Personnel Program Coordinator (TPPC) is responsible for coordinating the consistent development and implementation of the Technical Qualification Program throughout the Department of Energy. Concurrence with this Qualification Standard by the Technical Personnel Program Coordinator is indicated by the signature below.

The Technical Excellence Executive Committee (TEEC) consists of senior Department of Energy managers. This Committee is responsible for reviewing and approving the Qualification Standard for Department-wide application. Approval of this Qualification Standard by the Technical Excellence Executive Committee is indicated by the signature below.

NOTE: The signatures below reflect concurrence and approval of this Qualification Standard for interim Implementation. Final concurrence and approval will occur in December 1995, pending comments received based upon implementation.

CONCURRENCE:

_____	_____
Associate Deputy Secretary for Field Management	Technical Personnel Program Coordinator

APPROVAL:

_____
Chairman
Technical Excellence Executive Committee

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U.S. DEPARTMENT OF ENERGY
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FUNCTIONAL AREA

Electrical Systems

PURPOSE

The Technical Qualification Program is divided into three levels of technical competence and qualification. The General Technical Base Qualification Standard establishes the base technical competence required of all Department of Energy defense nuclear facility technical personnel. The Functional Area Qualification Standards build on the requirements of the General Technical Base Qualification Standard and establish Department-wide functional competence requirements in each of the identified functional areas. Office/facility-specific qualification standards establish unique operational competency requirements at the Headquarters or Field element, site, or facility level.

The Electrical Systems Functional Area Qualification Standard establishes common functional area competency requirements for all Department of Energy electrical systems technical personnel who provide management oversight or direction impacting the safe operation of defense nuclear facilities. Satisfactory and documented completion of the competency requirements contained in this Standard ensures that technical employees possess the minimum requisite competence to fulfill their functional area duties and responsibilities. Additionally, these competency requirements provide the functional foundation to assure successful completion of the appropriate Office/facility-specific qualification standard.

APPLICABILITY

This Standard applies to all Department of Energy electrical systems technical personnel who provide management direction or oversight impacting the safe operation of defense nuclear facilities. Personnel designated by Headquarters or Field element line management as participants in the Technical Qualification Program are required to meet the requirements of this Standard as defined in DOE Order 3410.

IMPLEMENTATION REQUIREMENTS

The competencies contained in the Standard are divided into the following four categories:

1. General Technical
2. Regulatory
3. Administrative
4. Management, Assessment, and Oversight

Each of the categories is defined by one or more competency statements indicated by bold print. The competency statements define the expected knowledge and/or skill that an individual must

possess, and are requirements. Each competency statement is further explained by a listing of supporting knowledge and/or skill statements. The supporting knowledge and/or skill statements are not requirements and do not necessarily have to be fulfilled to meet the intent of the competency.

The competencies identify a familiarity level, working level, or expert level of knowledge; or they require the individual to demonstrate the ability to perform a task or activity. These levels are defined as follows:

Familiarity level is defined as basic knowledge of or exposure to the subject or process adequate to discuss the subject or process with individuals of greater knowledge.

Working level is defined as the knowledge required to monitor and assess operations/activities, to apply standards of acceptable performance, and to reference appropriate materials and/or expert advice as required to ensure the safety of Departmental activities.

Expert level is defined as a comprehensive, intensive knowledge of the subject or process sufficient to provide advice in the absence of procedural guidance.

Demonstrate the ability is defined as the actual performance of a task or activity in accordance with policy, procedures, guidelines, and/or accepted industry or Department practices.

Headquarters and Field elements shall establish a program and process to ensure that all defense nuclear facility technical personnel required to participate in the Technical Qualification Program meet the competency requirements contained in this Standard. Documentation of the completion of the requirements of this Standard shall be included in the employee's training and qualification record.

In select cases, it may necessary to exempt an individual from completing one or more of the competencies in this Functional Area Qualification Standard. Exemptions from individual competencies shall be justified and documented in accordance with DOE Order 3410. Exemptions shall be requested by the individual's immediate supervisor, and approved one level above the individual's immediate supervisor.

Equivalencies may be granted for individual competencies based upon an objective evaluation of the employee's prior education, experience, and/or training. Documentation of equivalencies shall indicate how the competency requirements have been met. The supporting knowledge and/or skill statements may be considered when evaluating an individual's ability with respect to each competency requirement.

Training shall be provided to employees in the Technical Qualification Program who do not meet the competencies contained in the qualification standard. Departmental training will be based upon supporting knowledge and/or skill statements similar to the ones listed for each of the competency statements. Headquarters and Field elements should use the supporting knowledge and/or skill statements as a basis for evaluating the content of any training courses used to provide individuals with the requisite knowledge and/or skill required to meet the qualification standard competency statements.

DUTIES AND RESPONSIBILITIES

The following are duties and responsibilities normally expected of defense nuclear facility technical personnel assigned to the electrical systems functional area:

A Review the management and oversight of the design and construction process.

B. Update knowledge and skills in electrical codes and technology.

C. Prepare and review contracting mechanisms (cost plus award fee, cost plus fixed fee, etc.), contractor performance evaluations, and contract specifications, etc.

D. Serve as a subject matter expert and technical resource for electric systems personnel in training and other technical matters.

E. Inspect/evaluate electrical systems for safe and efficient operation, maintenance and testing.

F. Conduct/perform accident investigations, root cause analysis and problem-solving activities.

G. Participate in establishing and/or reviewing Department of Energy electrical policy and requirements.

H. Evaluate contractor compliance with relevant Department of Energy Orders, standards, codes, Management & Operating contractor maintenance procedures, etc.

I. Evaluate electrical programs/operations/safety.

J. Review safety documentation.

K. Verify the application of quality assurance principles to electrical systems and safety.

Additional duties and responsibilities specific to the site, the facility, the operational activities, and/or the involved organizations shall be contained in the facility-specific qualification standard(s).

BACKGROUND AND EXPERIENCE

The U. S. Office of Personnel Management's Qualification Standards Handbook establishes minimum education, training, experience, or other relevant requirements applicable to a particular occupational series/grade level, as well as alternatives to meeting specified requirements.

The preferred education and experience for electrical systems personnel is:

1. Education:

   Bachelor of Science degree in Electrical Engineering from an accredited institution or meet the alternative requirements specified in the Qualification Standards Handbook for the GS-0800, Professional Engineering Series.

2. Experience:

   Industry/facility/operations/other background that has provided experience in electrical engineering. Experience can be demonstrated through possession of the competencies outlined in this Standard.

REQUIRED COMPETENCIES

The competencies contained in this Standard are distinct from those competencies contained in the General Technical Base Qualification Standard. All electrical systems personnel must complete the competency requirements of the General Technical Base Qualification Standard prior to or in parallel with the completion of the competency requirements contained in this Standard. Each of the competency statements defines the level of expected knowledge and/or skill that an individual is required to possess to meet the intent of this Standard. The supporting knowledge and/or skill statements further describe the intent of the competency statements but are not requirements.

1. GENERAL TECHNICAL

1.1 Electrical systems personnel shall demonstrate a working level knowledge of electrical and circuit theory, terminology, theorems, laws, and analysis.

Supporting Knowledge and/or Skills

a. Explain the basic law of electrostatics.

b. Define the following terms and their relationship in energized circuits:

- Resistance
- Capacitance
- Inductance
- Reactance

c. Explain the following fundamental laws of circuit analysis:

- Ohm's Law
- Kirchoff's law

d. Explain the use of the following theorems in network analysis and describe their application in circuit reduction techniques:

- Thevenin's Theorem
- Norton's Theorem
- Maximum Power Transfer Theorem
- Superposition Theorem

e. Discuss the fundamental relationships in direct current (DC) circuits among voltage, current, resistance, and power.

f. Explain the treatment of inductance and capacitance values in steady-state direct current circuits.

g. Discuss the fundamental relationships in alternating current (AC) circuits among voltage, current, resistance, reactance, impedance, power, and power factor.

h. Describe how the following methods produce a voltage:

- Electro-chemistry
- Static electricity
- Magnetic induction
- Piezo-electric effect

- Thermo-electricity

- Photoelectric effect
- Thermonic emission

i. Using appropriate data, calculate the total resistance for a circuit containing combinations of parallel and series resistance.

j. Using appropriate data for a circuit, calculate the reactance of that circuit.

1.2 Electrical systems personnel shall have a working level knowledge of direct current (DC) generators.

Supporting Knowledge and/or Skills

a. Describe the relationship between shaft speed, field flux and generated voltage.

b. Define the following:

- Electromotive force
- Excitation
- Compounding
- Armature
- Terminal voltage
- Load current
- Shunt windings
- Series windings

c. State the purpose of the following components of a direct current machine:

- Armature
- Rotor
- Stator
- Field

d. Describe self-excited and separately excited generators.

e. Describe the operation of compound-wound generators.

f. Describe how the terminal voltage of a direct current generator is adjusted.

g. State the basis behind each direct current generator rating.

h. Describe the internal losses found in a direct current generator.

i. Describe the differences in construction between a shunt-wound and a series-wound direct current generator with respect to the relationship between the field and the armature.

j. Describe the relationship between the shunt and series fields for cumulatively-compounded and differentially-compounded direct current generators.

k. Describe the voltage-versus-current characteristics for a flat-compounded, over-compounded, and under-compounded direct current generator.

1.3 Electrical systems personnel shall have a working level knowledge of direct current (DC) motors.

Supporting Knowledge and/or Skills

a. Describe the basic construction and operation of the following four types of direct current motors:

- Shunt
- Separately excited
- Compound-wound
- Series

b. State the function of torque in a direct current motor and how it is developed.

c. Describe the function of counter-electromotive force (CEMF) and how it is developed in a direct current motor.

d. Describe the relationship between field current and magnetic field size in a direct current motor.

e. Describe how to adjust the speed of a direct current motor.

f. Describe the relationship between armature current and torque produced in a direct current motor.

g. Describe the torque-versus-speed characteristics for a shunt-wound and a series-wound direct current motor.

h. Explain why starting resistors may be necessary for large direct current motors.

1.4 Electrical systems personnel shall demonstrate a working level knowledge of battery construction, voltage production, and hazards.

Supporting Knowledge and/or Skills

a. Using a cutaway drawing of a simple multi-cell storage battery, identify the following components and discuss their function:

- Positive terminal
- Negative terminal
- Electrode
- Cell

b. Describe the hazards associated with storage batteries.

c. Define the following terms:

- Voltaic cell
- Battery
- Electrode
- Electrolyte
- Specific gravity
- Ampere-hour

d. Describe the operation of a simple voltaic cell.

e. Explain the relationship between specific gravity and state of charge of a lead-acid battery.

f. Describe the relationship between total battery voltage and individual cell voltage for a series-connected battery.

g. Explain the advantage of connecting a battery in parallel with respect to current-carrying capability.

h. Describe the difference between primary and secondary cells with respect to recharge capability.

i. State the advantages of each of the following types of batteries:

- Carbon-zinc cell
- Alkaline cell
- Nickel-cadmium cell
- Edison cell
- Mercury cell

j. Explain how gas generation is minimized for a lead-acid battery.

k. Explain how heat is generated in a lead-acid battery.

1.5 Electrical systems personnel shall demonstrate a working level knowledge of basic alternating current (AC) theory.

Supporting Knowledge and/or Skills

a. Define the effective value of an alternating current relative to direct current (DC).

b. Describe the relationship between maximum, average, and root-mean-square (RMS) values of voltage and current in an alternating current waveform.

c. Using a diagram of two sine waves, describe the phase relationship between the two waves.

1.6 Electrical systems personnel shall demonstrate a working level knowledge of the construction and operation of alternating current (AC) generators.

Supporting Knowledge and/or Skills

a. Describe the basic construction and operation of a simple alternating current generator.

b. Describe the development of a sine-wave output in an alternating current generator.

c. Define the following terms in relation to alternating current generation:

- Radians/second
- Hertz
- Period

d. Using the type and application of an alternating current generator, describe the operating characteristics of that generator including methods of voltage production, advantages of each type, and methods for paralleling.

e. State the purpose of the following components of an alternating current generator:

- Field
- Armature
- Prime mover
- Rotor
- Stator
- Slip rings

f. Using the speed of rotation and number of poles, calculate the frequency output of an alternating current generator.

g. List the three losses found in an alternating current generator.

h. Given the prime mover input and generator output, determine the efficiency of an alternating current generator.

i. Describe the basis for the kilowatt and kilovolt-ampers ratings of an alternating current generator.

j. Describe the conditions that must be met prior to paralleling two alternating current generators including, consequences of not meeting these conditions.

k. Describe the difference between a stationary field, rotating armature alternating current generator and a rotating field, stationary armature alternating current generator.

l. Explain the differences between a wye-connected and delta-connected alternating current generator including advantages and disadvantages of each type.

1.7 Electrical systems personnel shall demonstrate a working level knowledge of various types of alternating current (AC) motors, including operating characteristics, method of torque production, and the advantages of specific motor types.

Supporting knowledge and/or Skills

a. Describe how an alternating current motor produces a rotating magnetic field.

b. Describe how an alternating current motor produces torque.

c. Using field speed and rotor speed, calculate percent slip in an alternating current motor.

d. Explain the relationship between speed and torque in an alternating current induction motor.

e. Describe how torque is produced in a single-phase alternating current motor.

f. Explain why an alternating current synchronous motor does not have starting torque.

g. Describe how an alternating current synchronous motor is started.

h. Describe the effects of over and under-exciting an alternating current synchronous motor.

i. State some applications of the following types of alternating current motors:

- Induction
- Single-phase
- Synchronous

j. Describe the differences in starting and operating characteristics of premium efficiency motors.

k. Explain the following motor terms:

- Nameplate Revolutions Per Minute (RPM)
- National Electrical Mainframe Association (NEMA) frame size
- Service factor
- Insulation class
- National Electrical Mainframe Association (NEMA) design designation (letter)
- Non-symmetrical load

1.8 Electrical systems personnel shall demonstrate a working level knowledge of alternating current (AC) reactive components, including inductive and capacitive reactance and phase relationships in reactive circuits.

Supporting knowledge and/or Skills

a. Define the following:

- Inductive reactance
- Capacitive reactance
- Impedance
- Resonance
- Power factor
- Non-symmetrical load

b. Describe the effect of the phase relationship between current and voltage in an inductive circuit.

c. Describe the effect on phase relationship between current (I) and voltage (E) in a capacitive circuit.

d. Determine the value for total current (IT) in a simple parallel resistance-capacitance-inductance (R-C-L) alternating current circuit.

e. Describe the relationship between apparent, true, and reactive power.

f. Describe the indications of an unbalanced load in a three-phase power system.

g. Discuss circuit considerations required for non-symmetrical loads.

1.9 Electrical systems personnel shall demonstrate a working level knowledge of electrical transmission and distribution systems.

Supporting Knowledge and/or Skills

a. Explain the differences between transmission and distribution systems.

b. Identify and discuss the advantages and disadvantages associated with underground and above-ground distribution systems.

c. Describe the function and importance of the following control and protective devices:

- Circuit breakers
- Protective relays
- Fuses
- Transient protection

d. Compare and contrast the characteristics of three-phase and single-phase distribution systems.

e. Discuss the principles associated with ensuring continual power availability during electrical outages.

f. Explain the following terms as they relate to power systems:

- Fault current
- Available fault current
- Fault duty

g. Discuss the safety considerations associated with high voltage transmission systems.

h. Discuss the principles of electromagnetic radiation.

i. Explain the requirements for and uses of alternate power supplies.

j. Discuss the effects on facility operations of failure of electrical components.

1.10 Electrical systems personnel shall demonstrate a working level knowledge of transformers.

Supporting Knowledge and/or Skills

a. Define the following terms as they apply to transformers:

- Mutual induction
- Turns ratio
- Impedance ratio
- Efficiency

b. Describe the differences between a wye-connected and delta-connected transformer.

c. Using the type of connection and turns ratios for the primary and secondary of a transformer, calculate voltage, current, and power for each of the following types:

- Delta - Delta
- Delta - Wye
- Wye - Delta
- Wye - Wye

d. State the applications of each of the following types of transformers:

- Distribution
- Power
- Control
- Auto
- Isolation
- Instrument potential
- Instrument current

e. Describe the hazardous materials that are associated with transformers.

1.11 Electrical personnel shall demonstrate a working level knowledge of electrical test instruments and measuring devices.

Supporting Knowledge and/or Skills

a. Explain the following meter movements:

- D-Arsonval
- Electro-dynamometer
- Moving iron vane

b. Describe the purpose and method of operation of the following in-place measuring devices:

- Voltmeter
- Ammeter
- Ohmmeter
- Wattmeter
- Ampere-hour meter
- Power factor meter
- Ground detector
- Synchroscope
- Meggar

c. Describe safe methods for using the following portable test equipment:

- Ammeter
- Voltmeter
- Ohmmeter

1.12 Electrical systems personnel shall demonstrate a working level knowledge of safety and health fundamentals related to electrical systems and components.

Supporting Knowledge and/or Skills

a. Discuss the hazards associated with the use of corrosives (acids and alkalies).

b. Describe the general safety precautions necessary for the handling, storage, and disposal of corrosives.

c. Discuss the general safety precautions regarding toxic compounds.

d. Describe the criteria to determine if a compound is a health hazard and discuss the methods by which toxic compounds may enter the body.

e. Discuss the general safety precautions for the use, handling, and storage of compressed gases, specifically including: hydrogen, oxygen, and nitrogen.

f. Explain the difference between a flammable material and a combustible material.

g. Describe the general safety precautions regarding the use, handling, and storage of flammable and combustible materials.

h. Discuss the hazards associated with:

- Battery fluids and materials
- Transformer oils
- Cleaning solvents
- Epoxies
- Insulating and protective gases

i. Identify and discuss elements of an electrical safety program, including the following:

- Two-man rule
- Protective equipment
- Lockout and tagout
- Grounding
- Stored energy
- Component labelling

1.13 Electrical systems personnel shall demonstrate a familiarity level knowledge of the principles and concepts of natural phenomena hazards and their effect on electrical systems.

Supporting Knowledge and/or Skills

a. Discuss the potential impact on electrical systems at defense nuclear facilities from the following natural hazards:

- Flooding
- Wind
- Tornado
- Earthquake and/or other seismic events
- Fire
- Lightning

b. Briefly describe the safety measures and design features commonly used as safeguards against natural hazards.

1.14 Electrical systems personnel shall demonstrate a familiarity level knowledge of the various computer applications used in electrical systems engineering.

Supporting Knowledge and/or Skills

a. Identify and discuss at least one of the major computer programs used in electrical systems engineering.

b. Describe the applications of computer-aided design (CAD) as it relates to electrical systems design functions (e.g., load analysis, breaker coordination, fault calculations, conductor sizing, or voltage drop calculations).

c. Discuss the quality of electric power, including neutral harmonic currents, required for large computer systems.

d. Describe the use of computers in the monitoring and control of power systems.

e. Discuss the use of computers in circuit analysis and electrical system calculations.

1.15 Electrical systems personnel shall demonstrate a working level knowledge of electrical diagrams, including:

- **One-line diagrams**
- **Schematics**
- **Construction drawings**
- **As-built drawings**
- **Wiring diagrams**

Supporting Knowledge and/or Skills

a. Using a schematic, identify an electrical component by its symbology.

b. Using a logic diagram for a control circuit, identify and describe the effects of an action taken.

c. Using a one-line diagram, identify power sources and loads.

d. Using a one-line diagram or schematic diagram, analyze the effects of a component failure in a system.

e. Using a construction drawing, identify the emergency power supplies.

f. Discuss the origin and purpose of "as-built" drawings.

1.16 Electrical systems personnel shall demonstrate a familiarity level knowledge of maintenance management practices related to electrical activities.

Supporting Knowledge and/or Skills

a. Define each of the following maintenance-related terms and explain their relationship to each other.

- Corrective
- Planned
- Preventive
- Reliability Centered
- Predictive

b. Describe the elements of an effective work control program and the documentation used to control maintenance.

c. Discuss the importance of maintaining a proper balance of preventive and corrective maintenance.

d. Define the term "life limiting component" and discuss its impact on facility operation.

e. Identify typical maintenance performance indicators, and discuss their importance.

f. Discuss the relationship between maintenance and Conduct of Operations, Qualify Assurance, and Configuration Management.

g. Discuss the requirements for receiving and inspecting parts, materials, and equipment.

h. Describe the difference between temporary and permanent repairs/work and the requirements and controls in place to prevent inadvertent modifications.

2. REGULATORY

NOTE: When Department of Energy (DOE) directives are referenced in the qualification standard, the most recent revision should be used.

2.1 Electrical systems personnel shall demonstrate a working level knowledge of the electrical systems-related sections and/or requirements of Department of Energy, DOE Order 6430.1A, General Design Criteria, Division 1, General Requirements, and Division 16, Electrical.

Supporting Knowledge and/or Skills

a. Discuss the use of DOE Order 6430.1A, General Design Criteria, Division 1 in the identification of design requirements for electrical systems at Department facilities.

b. Describe the purpose, scope, and application of the requirements detailed in DOE Order 6430.1A, General Design Criteria, Division 16.

c. Determine contractor compliance with the applicable provisions of DOE Order 6430.1A, General Design Criteria.

d. Discuss the relationship between the National Electric Code and Division 16 of DOE Order 6430.1A, General Design Criteria.

e. Discuss the relationship between the American National Standards Institute (ANSI) standards and Division 16 of DOE Order 6430.1A, General Design Criteria.

f. Discuss what constitutes a safety class item as defined in DOE 6430.1A, General Design Criteria.

g. Discuss the application of single failure criteria to electrical systems.

h. Discuss the environmental qualification criteria for electrical system equipment.

i. Discuss the requirements for testing the capability of electrical systems as specified in DOE 6430.1A, General Design Criteria.

j. Discuss the criteria for generic human factors engineering considerations in DOE 6430.1A, General Design Criteria, as they apply to electrical systems.

k. Using a design package for an electrical system for a mechanical, civil, or structural application, determine the general design criteria requirements for the electrical system and components.

2.2 Electrical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy, DOE Order 5000.3, Occurrence Reporting and Processing of Operations Information.

Supporting Knowledge and/or Skills

a. State the purpose of the Order.

b. Define the following terms:

- Event
- Condition
- Facility
- Notification report
- Occurrence report
- Reportable occurrence

c. Discuss the Department's policy regarding the reporting of occurrences as outlined in the Order.

d. State the different categories of reportable occurrences and discuss each.

e. Refer to Attachment 1 of Order 5000.3 and discuss the role of electrical systems personnel in electrical systems-related reportable occurrences.

2.3 Electrical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy Standard, DOE-STD-1073-93, Guide for Operational Configuration Management Program.

Supporting Knowledge and/or Skills

a. Describe the purpose and objectives of the Operational Configuration Management Program.

b. Discuss what constitutes acceptable contractor compliance consistent with the requirements of DOE-STD-1073-93, Guide for Operational Configuration Management Program, for the following elements of the contractor's Configuration Management Plan:

- Program planning
- Equipment scope criteria
- Concepts and terminology
- Interfaces
- Databases
- Procedures

c. Discuss the following elements of the Configuration Management Program:

- Design requirements
- Document control
- Change control
- Assessments
- Design reconstitution adjunct

- Material condition and aging adjunct

d. Discuss the purpose, concepts, and general process for applying the graded approach to operational configuration management.

2.4 Electrical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy, DOE Order 4700.1, Project Management System.

Supporting Knowledge and/or Skills

a. Discuss the purpose, scope, and application of DOE Order 4700.1, Project Management System. Include in this discussion, key terms, essential elements, and personnel responsibilities and authorities.

b. Discuss the project management terminology for which definitions are provided in DOE Order 4700.1, Project Management System.

c. Discuss in detail the roles played by various management levels within the Department as they relate to the project management system.

d. Discuss the purpose of "critical decisions." Include in this discussion the responsible authorities for critical decisions.

e. Describe the process by which projects are designated.

2.5 Electrical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy, DOE Order 5700.6C, Quality Assurance, as it pertains to electrical systems.

Supporting Knowledge and/or Skills

a. Describe the types of documents related to electrical systems that should be controlled by a document control system.

b. Discuss the requirements for revision and distribution of controlled documents.

c. Discuss the determination of calibration frequency for electrical test equipment.

d. Describe the effect of using inappropriate calibration standards on electrical test equipment.

e. Discuss the key elements of the procurement process for electrical systems as described in DOE Order 5700.6C, Quality Assurance.

2.6 Electrical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy, DOE Order 5480.21, Unreviewed Safety Questions.

Supporting Knowledge and/or Skills

a. Discuss the reasons for performing an Unreviewed Safety Question determination.

b. Define the following terms:

- Accident Analyses
- Safety Evaluation
- Technical Safety Requirements

c. Describe the situations for which a safety evaluation is required to be performed.

d. Define the conditions for an Unreviewed Safety Question.

e. Describe the responsibilities of contractors authorized to operate defense nuclear facilities regarding the performance of safety evaluations.

f. Describe the actions to be taken by a contractor upon identifying information that indicates a potential inadequacy of a previous safety analyses or, a possible reduction in the margin of safety, as defined in the Technical Safety Requirements.

2.7 Electrical systems personnel shall demonstrate a familiarity level knowledge of the Technical Safety Requirements as described in Department of Energy, DOE Order 5480.22, Technical Safety Requirements.

Supporting Knowledge and/or Skills

a. Discuss the purpose of the Technical Safety Requirements.

b. Describe the responsibilities of contractors authorized to operate defense nuclear facilities regarding the Technical Safety Requirements.

c. Define the following terms and discuss the purpose of each:

- Safety Limit
- Limiting Control Settings
- Limiting Conditions for Operation
- Surveillance Requirements

d. Describe the general content of each of the following sections of the Technical Safety Requirements:

- Use and Application
- Safety Limits
- Operating Limits
- Surveillance Requirements
- Administrative Controls
- Basis
- Design Features

2.8 Electrical systems personnel shall demonstrate a familiarity level knowledge of Nuclear Safety Analysis Reports as described in Department of Energy, DOE Order 5480.23, Nuclear Safety Analysis Reports.

Supporting Knowledge and/or Skills

a. Discuss the basic purposes and objectives of Nuclear Safety Analysis Reports.

b. Describe the responsibilities of contractors authorized to operate DOE nuclear facilities regarding the development and maintenance of a Nuclear Safety Analysis Report.

c. Define the following terms and discuss the purpose of each:

- Design Basis
- Authorization Basis
- Engineer Safety Features
- Safety Analysis

d. Describe the requirements for the scope and content of a Nuclear Safety Analysis Report and discuss the general content of each of the required sections of a Nuclear Safety Analysis Report.

e. Discuss the uses that contractor management makes of Nuclear Safety Analysis Reports.

2.9 Electrical systems personnel shall demonstrate a familiarity level knowledge of the following Department of Energy Standards and Order related to natural phenomena hazards:

- **DOE-STD-1020-94, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities**
- **DOE-STD-1021-93, Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components**
- **DOE-STD-1022-94, Natural Phenomena Hazards Site Characterization Criteria**
- **DOE Order 5480.28, Natural Phenomena Hazards Mitigation**

Supporting Knowledge and/or Skills

a. Describe the purpose, scope, and application of the requirements detailed in the listed standards and Order.

b. Discuss the graded approach process that Department line management uses to determine an appropriate level of coverage by electrical systems personnel. Include in this discussion the factors that may influence the level of coverage.

c. Determine contractor compliance with the listed documents as they apply to contract design requirements and electrical system activities at a defense nuclear facility.

2.10 Electrical systems personnel shall demonstrate a working level knowledge of the following Institute of Electrical and Electronic Engineers (IEEE) Color Book Series as they apply to the design, construction and operation of nuclear facilities.

- **Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE-STD-141-1976 (IEEE Red Book), Electrical Power Distribution**
- **Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE-STD-242-1975 (IEEE Buff Book), Protection and Coordination**
- **Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE-STD-399-1980 (IEEE Brown Book), Power Systems Analysis**
- **Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE-STD-142-1982 (IEEE Green Book), Grounding**
- **Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE-STD-446-1987 (IEEE Orange Book), Emergency and Standby Power**
- **Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE-STD-493-1990 (IEEE Gold Book), Power Systems Reliability**
- **Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE-STD-241-1990 (IEEE Gray Book), Commercial Building Power Systems**
- **Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE-STD-739-1984 (IEEE Bronze Book), Energy Conservation in Industrial Facilities**

Supporting Knowledge and/or Skills

a. Refer to Institute of Electrical and Electronic Engineers (IEEE) Red Book and discuss electrical power distribution. Include the following in your discussion:

- Basic design considerations and electrical distribution design
- Voltage considerations
- Surge voltage protection techniques
- System protective devices
- Power factor and its effects in electrical distribution systems
- Power switching, transformation, and motor-control apparatus
- Cable system basics
- Busway design

b. Refer to Institute of Electrical and Electronic Engineers Buff Book and discuss protection and coordination. Include the following in your discussion:

- Fault calculations
- Short-circuit current calculations for single and three-phase circuits.
- Instrument transformer basics
- Protective relay selection and application
- Fuses selection and application
- Low-voltage circuit breaker fundamentals
- Ground-fault protection fundamentals
- Conductor, motor, transformer, generator, and bus and switchgear protection
- Maintenance, testing, and calibration of electrical systems

c. Refer to Institute of Electrical and Electronic Engineers Brown Book and discuss power system analysis. Include the following in your discussion:

- Power system analysis fundamentals
- Power system analysis analytical procedures
- System modeling fundamentals

d. Refer to Institute of Electrical and Electronic Engineers Green Book and discuss grounding. Include the following in your discussion:

- Electrical system grounding fundamentals
- Electrical equipment grounding fundamentals
- Static and lightning grounding fundamentals

e. Refer to Institute of Electrical and Electronic Engineers Orange Book and discuss emergency and standby power. Include the following in your discussion:

- Emergency and standby power guidelines
- Generator and electric utility system fundamentals
- Stored energy system fundamentals
- Protection device fundamentals

f. Refer to Institute of Electrical and Electronic Engineers Gold Book as a reference, discuss power systems reliability. Include the following in your discussion:

- Planning and design basics
- Improving existing electrical system reliability
- Reliability analysis basic concepts

g. Refer to Institute of Electrical and Electronic Engineers Grey Book and discuss commercial building power systems. Include the following in your discussion:

- Lighting design considerations
- Electric space heating fundamentals

h. Refer to Institute of Electrical and Electronic Engineers Bronze Book and discuss energy conservation in industrial facilities. Include the following in your discussion:

- Energy conservation program fundamentals
- Translating energy into cost
- Load management fundamentals
- Electrical machines and equipment conservation consideration fundamentals

3. ADMINISTRATIVE

NOTE: When Department of Energy (DOE) directives are referenced in the qualification standard, the most recent revision should be used.

3.1 Electrical systems personnel shall demonstrate the ability to communicate (both oral and written) when working or interacting with the contractor, stakeholders, and other internal and external organizations.

Supporting Knowledge and/or Skills

a. Identify the various internal and external groups with whom electrical systems personnel must interface in the performance of their duties.

b. Apply written communication skills in the development of:

- Assessment reports
- Technical reports
- Technical papers

c. Apply effective and appropriate communications skills when providing specific work or task directions to contractors.

4. MANAGEMENT, ASSESSMENT, AND OVERSIGHT

NOTE: When Department of Energy (DOE) directives are referenced in the qualification standard, the most recent revision should be used.

4.1 Electrical systems personnel shall demonstrate the ability to determine the adequacy of local compliance with the electrical systems-related sections and/or requirements of Department of Energy, DOE Order 6430.1A, General Design Criteria, Divisions 1 and 16.

Supporting Knowledge and/or Skills

a. Using Divisions 1 and 16 of the DOE Order 6430.1A, General Design Criteria, prepare an action plan which adequately outlines interviews and observations to be conducted, and which details documents to review during an evaluation of contractor compliance against the requirements of the Order.

b. Using an appropriate level of coverage, evaluate a contractor's compliance with the requirements of Division 16 of DOE Order 6430.1A, General Design Criteria. During this evaluation, demonstrate the ability to properly conduct interviews, observations, and document reviews.

c. Using data from an evaluation, analyze the results to determine contractor compliance or noncompliance with the requirements.

d. Using the results from an analysis of contractor compliance or noncompliance, document and communicate the results to contractor and Department line management.

e. Using a system's terminal manuals and design drawings, inspect the system for compliance with Division 16 of DOE Order 6430.1A, General Design Criteria.

f. Discuss conductor identification using color coding of low voltage (120-400 volt) systems in single and three-phase systems with the requirements of Division 16 of DOE Order 6430.1A, General Design Criteria.

4.2 Electrical systems personnel shall demonstrate the ability to evaluate contractor activities and reports controlled by Department of Energy, DOE Order 5000.3B, Occurrence Reporting and Processing of Operations Information.

Supporting Knowledge and/or Skills

a. Using an occurrence report and using DOE Order 5000.3B, Occurrence Reporting and Processing of Operations Information, as a reference, determine the following:

- The adequacy of the review process used
- Whether causes were appropriately defined
- Whether corrective actions addressed causes
- Whether the lessons learned were appropriate
- Whether corrective actions have been completed

b. Using an occurrence report involving electrical systems activities, identify and discuss the factors contributing to the occurrence.

4.3 Electrical systems personnel shall demonstrate an ability to assess contractor work activities against the requirements specified in the Institute of Electrical and Electronic Engineers (IEEE) Color Book Series, and American National Standards Institute (ANSI) Standards.

Supporting Knowledge and/or Skills

a. Describe the purpose, scope, and application of the requirements for electrical systems detailed in the Institute of Electrical and Electronic Engineers Standards.

b. Discuss what constitutes acceptable contractor performance consistent with the requirements of the Institute of Electrical and Electronic Engineers Standards.

c. Using the above codes and standards as applicable, evaluate a contractor's compliance with the requirements of the codes and standards. During the evaluation, demonstrate the ability to properly conduct interviews, observations, and document reviews.

d. Using data from an evaluation, analyze the results to determine contractor compliance or noncompliance with the requirements.

e. Using the results from an analysis of contractor compliance or noncompliance, document and communicate the results to contractor and Department line management.

f. Using a design package for an electrical system, demonstrate the ability to verify compliance with the appropriate Institute of Electrical and Electronic Engineers Standards.

4.4 Electrical systems personnel shall demonstrate a familiarity level knowledge of financial management practices and the application of contractor resources to meet commitments to the quality, safety, cost, and schedule of electrical systems.

Supporting Knowledge and Skills

a. Describe the process for preparing cost estimates and budgets.

b. Describe and contrast direct and indirect costs. List ways to reduce indirect costs.

c. Define and explain the relationship between the following terms:

- Budgeted cost of work scheduled (BCWS)
- Budgeted cost of work performed (BCWP)
- Actual cost of work performed (alternating current WP)
- Earned value (EV)

d. Describe the types of earned value, and how they are measured.

e. Describe the types of data required to forecast cost and schedule performance.

f. Define the term "estimate at completion" (EAC).

g. Discuss the importance of formal change control in relation to project management.

4.5 Electrical systems personnel shall demonstrate the ability to perform project management duties as required to provide electrical systems technical support to a project.

Supporting Knowledge and/or Skills

a. Support the preparation of a Project Execution Plan.

b. Evaluate a Work Breakdown Structure (WBS).

c. Evaluate a project's critical path schedule.

d. Using the results from an analysis of contractor noncompliance, determine the potential implications and describe how to communicate the results to contractor and Department management.

4.6 Electrical systems personnel shall demonstrate a familiarity level knowledge of the Department of Energy (DOE) project management system including the application of contractor resources to meet commitments to quality, safety, cost, and schedule.

Supporting Knowledge and/or Skills

a. Explain the purpose of project management and describe the phases of a typical project.

b. Describe the primary roles and responsibilities of electrical systems personnel as outlined in DOE Order 4700.1, Project Management System.

c. Describe typical documents and data sources utilized by electrical systems personnel in project management.

d. Identify and explain the major elements of a project, and discuss their relationship.

e. Explain the purpose and use of a project execution plan.

f. Discuss the role of configuration management as it relates to project management.

g. Explain the use of safety plans in the management of projects.

h. Discuss the relationship between work breakdown structure (WBS) and cost and schedule.

i. Describe the purpose and use of work packages and/or planning packages.

j. Describe the purpose of schedules, and discuss the use of milestones and activities.

k. Describe the critical path method of scheduling.

l. Explain the concept of a project management baseline and describe the four baselines used in project management.

4.7 Electrical systems personnel shall demonstrate a familiarity level knowledge of the Department of Energy/facility contract provisions necessary to provide oversight of a contractor's performance.

Supporting Knowledge and/or Skills

a. Describe the role of electrical systems personnel in contractor oversight.

b. Compare and contrast the following:

- The Department of Energy's expectations of a Management and Operating (M&O) contractor.
- Management and Operating (M&O) contractor's expectations of the Department of Energy.

c. Discuss the key elements and features of an effective Department of Energy Management and Operating (M&O) contractor relationship.

4.8 Electrical systems personnel shall demonstrate a working level knowledge of assessment techniques, reporting, and follow-up actions as they apply to contractor performance.

Supporting Knowledge and/or Skills

a. Describe the role of electrical systems personnel in performance oversight of government-owned, contractor-operated (GOCO) facilities.

b. Describe the assessment requirements and limitations associated with the interface of electrical systems personnel and contractor employees.

c. Describe how planning, observations, interviews, and document research are used during an assessment.

d. Explain the essential elements of a performance-based assessment including investigation, fact-finding, and reporting. Include a discussion of the essential elements and processes of the following assessment activities:

- Exit interviews
- Closure process
- Tracking to closure
- Follow-up
- Contractor corrective action implementation

e. Describe the actions to be taken if the contractor challenges the assessment findings and explain how such challenges can be avoided.

4.9 Electrical systems personnel shall demonstrate the ability to assess the activities of contractor and/or Federal electrical systems employees and make all necessary reports.

Supporting Knowledge and/or Skills

a. Using different sets of performance data, compare and contrast the data to highlight acceptable and unacceptable work performance.

b. Describe the methods by which noncompliance is determined and communicated to contractor and Department management.

c. Describe the role of electrical systems personnel in the contractor performance evaluation process.

d. Participate in the evaluation of a contractor's performance.

e. Conduct an interview during an occurrence investigation.

f. Develop an assessment report.

g. Participate in formal meetings between Department management and senior contractor management to discuss the results of electrical systems assessments.

4.10 Electrical systems personnel shall demonstrate a working level knowledge of problem analysis principles and the ability to apply techniques necessary to identify problems, determine potential causes of problems, and identify corrective action(s).

Supporting Knowledge and/or Skills

a. Describe and explain the application of problem analysis techniques including the following:

- Root cause analysis
- Causal factor analysis
- Change analysis
- Barrier analysis
- Management oversight risk tree (MORT) analysis

b. Describe and explain the application of the following root cause analysis processes in the performance of occurrence investigations:

- Event and causal factors charting
- Root cause coding
- Recommendation generation

c. Using event and/or occurrence data, apply problem analysis techniques and identify the problems and how they could have been avoided.

d. Participate in at least one Type A, B, or C investigation.

e. Participate in at least one contractor or Department problem analysis and critique the results.

f. Using data, interpret two fault tree analyses.

4.11 Electrical systems personnel shall demonstrate a familiarity level knowledge of Department of Energy (DOE) maintenance management requirements as defined in DOE Order 4330.4B, Maintenance Management Program.

Supporting Knowledge and/or Skills

a. Explain the Department's role in the oversight of contractor maintenance operations.

b. Identify the key elements of a contractor maintenance plan as required by DOE Order 4330.4B, Maintenance Management Program.

c. Describe configuration control and its relationship to the maintenance work control process and the maintenance history file.

d. Describe the mechanisms for feedback of relevant information, such as trend analysis and instrumentation performance/reliability data, to identify necessary program modifications.

e. Review a contractor preventive maintenance activity and describe the preventive maintenance factors to be considered as the activity is planned.

f. Discuss the importance of post-maintenance testing and the elements of an effective post-maintenance testing program.

g. Review the results of post-maintenance testing activities and discuss the acceptance of post-maintenance testing.

h. Discuss the importance of maintaining a maintenance history.

i. Review a maintenance history file and discuss the potential implications of repeat maintenance items.

j. Explain the intent of a Maintenance Problem Analysis Program and discuss a maintenance problem where this program has been employed.

EVALUATION REQUIREMENTS

The following requirements shall be met to complete the Department-wide Electrical Systems Functional Area Qualification Standard. The evaluation process identified below serves as a measurement tool for assessing whether the participants have acquired the technical competencies outlined in this Standard.

1. Documented completion of the Department-wide General Technical Base Qualification Standard in accordance with the requirements contained in that standard.

2. Documented completion of the competency requirements listed in this functional area qualification standard. Documentation of the successful completion of these competency requirements may be satisfied by a qualifying official using any of the following methods:

   - Documented evaluation of equivalencies
   - Written examination
   - Documented oral evaluation
   - Documented observation of performance

CONTINUING TRAINING AND PROFICIENCY REQUIREMENTS

Electrical systems personnel shall participate in an Office/facility/position-specific continuing training and qualification program that includes the following elements:

1. Technical education and/or training covering topics directly related to the duties and responsibilities of electrical systems personnel as determined by line management. This may include courses and/or training provided by:

   - Department of Energy
   - Other Government agencies
   - Outside vendors
   - Educational institutions

2. Training covering topics that address identified deficiencies in the knowledge and/or skill of electrical systems personnel.

3. Training in areas added to the Electrical Systems Functional Area Qualification Standard since initial qualification.

4. Specific continuing training requirements shall be documented in Individual Development Plans (IDPs).